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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
999 18th STREET - SUITE 500
DENVER, COLORADO 80202-2466

SEP 16 1998

Ref: 8EPR-ER

CONFIDENTIAL

ACTION MEMORANDUM

SUBJECT: Request for a Time-Critical Removal Action at the Vasquez Boulevard and I-70 (aka North Denver Residential Soils) Site, City and County of Denver, Colorado.

FROM: Pete Stevenson, On-Scene Coordinator
Emergency Response Team

THROUGH: Steve Hawthorn, Supervisor
Emergency Response Unit

Douglas M. Skie, Director
Preparedness, Assessment & Emergency Response Program

TO: Max Dodson, Assistant Regional Administrator
Office of Ecosystems Protection & Remediation

Site ID#: 9R
Category of Removal: Time-Critical, Fund-Lead

I. PURPOSE

The Purpose of this Action Memorandum is to request and document approval for the proposed Removal Action described herein for portions of residential neighborhoods in the vicinity of Vasquez Boulevard and I-70, City and County of Denver, Colorado (the Site). The conditions at this Site meet the emergency criteria for a Removal Action. The Removal Action will involve excavation of soils containing elevated levels of lead and arsenic from residential properties at the Site.

II. SITE CONDITIONS AND BACKGROUND

Sampling conducted by the Colorado Department of Public Health and Environment (CDPHE) and the U.S. Environmental Protection Agency (EPA) in 1997/1998 has identified elevated levels of lead and arsenic in residential soils in the communities of Elyria and Swansea in Denver. Sources of contamination appear to be related primarily to historic smelting activities that occurred in the Denver area from the 1870s to the 1950s. The contaminated soils in residential areas at the Site are the subject of this Action Memorandum.

A. Site Description

1. Removal site evaluation

In 1997 CDPHE conducted limited sampling at the Vasquez Boulevard and I-70 site. Of 25 soil samples, six contained lead (Pb) and/or arsenic (As) above screening levels (500 ppm Pb and/or 70 ppm As).

In April of 1998, EPA sampled approximately 1200 residential properties, collecting 3550 samples. Properties with As ≥70 mg/kg and ≤399 mg/kg and with Pb between 500 and 1999 mg/kg numbered 248. Properties greater than 400 mg/kg As and greater than 2000 mg/kg Pb numbered 46. Of these 46, seven contained the higher values at a depth of 6", with surface soil being less contaminated. These properties do not pose an immediate threat and will be left for remedial action. One property is a parking lot, and one consists of an old house with flaking paint and no signs of children (EPA will alert the proper authorities regarding the paint issue). These remaining 37 properties, and others found in the Phase II sampling, have undergone more extensive sampling to better define the areas of contamination. Results indicate that a total of 21 properties remain as Removal Action candidates.

2. Physical Location

The Site is located in the northwest part of Denver and generally is bounded by the South Platte River on the West, Colorado Boulevard on the East, 38th Avenue on the South, and 52nd Avenue on the North. As of the date of this writing, a second phase of sampling has been conducted south to 35th Avenue. Another small area South of I-70 and West of I-25 - bordered by Fox on the West and Cahita Court on the East - has also been sampled in this second phase. Results have not yet been validated and released from this second phase.

3. Site Characteristics

The Site area was settled in 1851, four years after the first pioneers entered the valley. Approximately 5700 people currently live in Elyria and Swansea, the predominant neighborhoods in the Site area. Youth under 18 comprise 36% of the residents (twice the average of the City of Denver).

Soon after development of the area, it was presumably contaminated by wastes containing lead and arsenic from smelting operations in the area. At least three smelters operated in the area in the late 1800s. These smelters reportedly deposited wastes within or adjacent to the Site.

4. Release or threatened release into the environment of a hazardous substance, or pollutant or contaminant.

Arsenic and, to a lesser degree, lead have been identified at the Site as the contaminants of concern. Arsenic and lead are hazardous substances, as defined by Section 101 (14) of CERCLA. These hazardous substances may have been released into the residential soils by historic smelting activities and spread through the Community by aerial deposition. At least 21 properties contain arsenic and lead at levels of concern to the Removal Program.

Because arsenic contamination is found in unsodded areas that are used for recreation, there is also a potential for contaminated soil to be wind-blown and dust-sized particles to be transported by wind and human activities into additional yards and into homes. There are an estimated 6000 cubic yards of soil contaminated above the selected Removal Program health protective action level of 2000 ppm lead and/or 450 ppm arsenic.

5. NPL Status

The Site will be evaluated for possible NPL listing.

B. <u>Other Actions to Date</u>

1. Previous Actions

The only previous actions pertaining to this Site have related to the sampling of soils and sediments, and these activities have been discussed in previous sections of this document.

2. Current Actions

The proposed action described in this Action Memorandum will address contamination in residential yards. Removal of the soils, contaminated by unacceptable levels of arsenic and lead, is consistent with previously implemented actions in the Region.

C. State and Local Authorities' Roles

The State and local agencies are actively involved in EPA's activities at the Site. Many of the Site technical issues are discussed at the Working Group meetings which include representatives from EPA, CDPHE, Denver City and County Environmental Health Departments, and neighborhood groups.

III. THREATS TO PUBLIC HEALTH OR WELFARE, THE ENVIRONMENT, AND STATUTORY AND REGULATORY AUTHORITIES

A. Threats to Public Health or Welfare

Conditions at the Site present an imminent and substantial endangerment to human health and the environment and meet the criteria for initiating a Removal Action under 40 C.F.R. Section 300.415 (b) (2) of the National Contingency Plan (NCP). The following factors from Section 300.415 (b) (2) of the NCP form the basis for EPA's determination of the threat presented, and the appropriate action to be taken:

(i) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants, and

(iv) High levels of hazardous substances or pollutants and contaminants in soils largely at or near the surface, that may migrate.

There is a significant potential for continued exposure to nearby human populations with at least 21 properties, where children or pregnant women are present, which contain average Pb concentrations greater than 2000 ppm and/or As averages greater than 450 ppm in the upper 2 inches. EPA's toxicologist has reviewed the data and determined action levels for the Removal Action. Threats to human health and selection of health protection action levels are described in detail in the endangerment assessment.

B. Threats to the Environment

The primary threat identified is exposure to human populations.

IV. ENDANGERMENT DETERMINATION

The actual or threatened releases of hazardous substances from this Site, if not addressed by implementing the response action selected in this Action Memorandum, may present an imminent and substantial endangerment to public health or welfare or the environment. (See the attached memorandum dated July 24, 1998, from EPA Region VIII Toxicologist Christopher P. Weis, Ph.D., DABT, regarding "Exposure to Elevated Levels of Arsenic and Lead in Residential Soils" - Attachment 1).

V. PROPOSED ACTIONS AND ESTIMATED COSTS

A. Proposed Action

1. Proposed action description

The following represents factors considered in determining whether properties within the community will be included within EPA's time critical removal action. These criteria were developed with input from EPA toxicologists, technical staff, and CDPHE/Denver personnel. They are based on the need to provide immediate reduction in exposure to arsenic/lead contaminated soil. These factors are generally considered on a zone-by-zone basis to establish whether an individual zone should be addressed to safeguard the overall residential yard for a young child. Both current and potential future exposures must be considered in applying the criteria.

Currently 21 properties have tentatively been identified as candidates for this Removal Action. These and additional properties will be addressed as follow-up sampling results indicate that levels exceed the action levels and other criteria discussed above. Additional properties may be found that qualify for Removal. Further, soil on identified properties that do not exceed the Removal Action level may be removed for economic reasons if they are at or near the action level.

Zones on properties will generally be included in the Removal Action if the average surface soil concentration (top 2") exceeds 2000 mg/kg of lead or 450 mg/kg of arsenic. In these instances soil will be removed to a 12" depth - for vegetable gardens soil will be removed to 18". This strategy provides two layers of protection. A protective barrier of at least twelve inches of clean material will be established for all zones. Secondly, if in the future this barrier is disrupted, average surface concentrations will remain below a health protective level.

The following describes removal options designed to reduce exposure to elevated arsenic concentrations. In most instances removal and off-site disposal of contaminated soils above the action level will be the preferred action. This option provides the greatest level of certainty with respect to risk reduction. In certain instances other health protective options will be considered on a property-by-property basis.

a. The depth of all removals will be 12". This depth provides an adequate barrier between soil contamination, if any, and children. In vegetable gardens removal of 18" will provide adequate protection under typical day-to-day exposure scenarios.

b. Capping with 12" soil or 4" asphalt may be considered for areas meeting all the following conditions: (1) a removal is not feasible (a lot with many large trees that the homeowner does not want removed); (2) there is relative certainty that the land use will not change in the short term (e.g. the cap will not be disturbed); and (3) drainage will not be adversely affected.

c. Mixing through tilling may be considered for areas that (1) are marginally above the action level in the first 0-6" but below the action level at depth; and (2) are relatively large and unsodded such that a considerable cost savings would be realized. This option may also include sampling prior to tilling to confirm that deeper levels are well below the action level. This option will include post tilling sampling to assure that the desired reduction in average contaminant level has occurred. If this option is chosen at any residence, a re-evaluation of ARARs will be undertaken.

This Removal Action includes the following specific activities:

a. Contaminated soils will be removed, capped or tilled according to the above criteria.

b. Individual residences where soil is removed will be backfilled with clean soil and top soil to the original grade and landscaped with sod.

c. Structures and fencing on the properties will be left in place or returned to their original locations if removal is necessary. If fencing cannot be reused, it will be replaced.

d. Contaminated soils may be consolidated at a staging area and secured in storage prior to disposal.

e. Existing Shrubs and/or Bushes(defined as low, densely branched plants that impede soil removal): Removal and replacement with the same species, standard nursery stock, and number of plants.

f. Existing Perennial Plants: Removal and replacement with the same (to the extent possible) or similar species, approximate size, and number of plants.

g. Annual Plants: Removal with no replacement.

h. Existing Sprinkler Systems: If the existing system impedes soil removal or will not function after barrier soil is placed, removal and replacement with the same or similar system.

i. Existing Concrete, Asphalt, Brick Stone, or Tile Surfacing (sidewalks, driveways, parking,lots, pads): Remain in place and excavate around unless the existing surfacing has been damaged in the past to the extent that soils exceeding the action levels are exposed. If soils exceeding the action levels have been exposed, remove and replace the surfacing with equivalent materials, if necessary to prevent exposure. The original materials may also be used if soil is removed before replacement.

j. Existing Landscape Covers and Borders: Removal and replacement with equivalent materials in areas requiring remediation. The original materials may also be used if soil is removed before replacement and materials are not damaged during removal.

k. Outdoor Animals: Temporary relocation during remediation of individual properties located in areas requiring remediation.

l. Movable Buildings and Sheds: Temporary relocation during remediation, if remediation is necessary at that location.

m. Existing Vegetable Gardens Exceeding Action Levels: Removal of a maximum of 18 inches of soil; replacement with a minimum of, but not necessarily more than, 18 inches of suitable vegetable garden soil with characteristics acceptable to EPA. Suitable vegetable garden soil will consist of clayey or sandy loam soils having a specified minimum percentage of organic matter. Suitable grades and ground cover will be restored.

n. Prevention of Indoor Dust: Dust suppression measures will be utilized during Removal. If necessary, other measures, such as sealing of doors and windows with plastic, will be taken during remediation of individual properties. If necessary, portable air cooling devices will be offered to residents during this time period.

o. Existing Decks: Remain in place and excavate beneath and around as needed unless the existing deck impedes soil removal. Options: should existing deck impede soil removal, include removal of existing deck and replace with an equal deck or utilize "shot crete" under the deck.

Owners will be asked for permission to remediate their residential areas. Detailed plans will be developed for the properties which are undergoing remediation, and owners will be provided copies and an opportunity to discuss the plans. The removal schedule will be provided to the owner; and after the removal, replacement of sod, etc., each owner will review the action with the OSC and discuss any future activities.

2. Contribution to remedial performance

The Removal Action proposed by EPA for this Site is consistent with the long-term plans of the Remedial Program.

3. Description of alternative technologies

As described in Section VI, a flexible approach has been crafted for this Removal Action, based on site-specific circumstances. Alternative approaches, such as tilling, will be implemented where appropriate. No other alternative technologies are practical or effective to achieve the Removal Action objectives.

4. Engineering Evaluation/Cost Analysis (EE/CA)

An engineering evaluation/cost assessment is not required for this action. No alternative technologies are practicable or effective.

5. ARARs

This Removal Action will attain, to the extent practicable, considering the exigencies of the situation, ARARs of Federal OSHA and environmental, or more stringent state environmental or facility siting laws. (See Attachment 2 for further information.)

6. Project Schedule

The construction portion of this Removal Action is scheduled to begin in September of 1998 and is planned to be completed by December of 1998. Monitoring of landscape restoration will continue into the Spring of 1999. This work schedule may be extended if the additional sampling reveals that more properties are contaminated above the action level.

B. Estimated Costs

Extramural Costs:

Regional Allowance Costs	
ERRS	$590,000
Other Extramural Costs Not Funded From The Regional Allowance:	
START	$100,000
20% Extramural Costs Contingency	$140,000
TOTAL EXTRAMURAL COSTS	**$830,000**

Intramural Costs:

Intramural Direct Costs	$ 50,000
Intramural Indirect Costs	$105,000
TOTAL INTRAMURAL COSTS	**$155,000**

TOTAL REMOVAL PROJECT CEILING **$985,000**

VI. EXPECTED CHANGE IN THE SITUATION SHOULD ACTION BE DELAYED OR NOT TAKEN

If no removal action is taken at the Site or if the action is delayed, the residents in the area will continue to be exposed to high levels of lead and arsenic. The endangerment assessment indicates that children have an increased chance of developing blood lead levels or arsenic toxicity that may cause irreversible health effects. The potential for migration of the contaminants exists in the event of runoff from rainstorm/flooding or through wind dispersion. These processes could spread contamination into previously uncontaminated areas nearby.

VII. OUTSTANDING POLICY ISSUES

As of the date of this Action Memorandum, EPA, CDPHE, and the City & County of Denver intend to pursue a long-term Remedial Action. This Removal Action only addresses those properties with high levels of contamination at the surface. The Remedial Program is already active and dealing with the long-term policy issues.

VIII. ENFORCEMENT

A confidential Enforcement Memorandum is included - Attachment 3.

IX. RECOMMENDATION

This decision document represents the selected Removal Action for the Vasquez Boulevard and I-70 Site, City and County of Denver, Colorado, developed in accordance with CERCLA, as amended, and is consistent with the NCP. This decision is based on the administrative record for the site.

Conditions at the Site meet the NCP §300.415 (b) (2) criteria for a removal, and I recommend your approval of the proposed Removal Action. The total project ceiling will be $985,000. Of this amount, an estimated $830,000 comes from the Regional removal allowance.

Approve: Max H Dodson

Date: 9/16/98

Max H. Dodson

Disapprove:_______________________

Date:__________

Max H. Dodson
Assistant Regional Administrator
Office of Ecosystems Protection and Remediation

Attachments:

Attachment 1:	Memorandum from EPA Toxicologist
Attachment 2:	ARARs
Attachment 3:	Enforcement Memorandum

Attachment 1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII (8EPR-PS)
999 18th STREET - SUITE 500
DENVER, COLORADO 80202-2466

Region VIII

JUL 27 1998

MEMORANDUM

SUBJECT: Exposure to elevated levels of arsenic and lead in residential soils in the vicinity of Vasquez Blvd. and I-70 may pose an imminent and substantial endangerment to public health.

FROM: Christopher P. Weis, Ph.D., DABT.
Regional Toxicologist

TO: Peter Stevenson
On Scene Coordinator

This memorandum addresses recently characterized metal contamination from lead and arsenic in residential surface soils in specific neighborhoods in the vicinity of Vasquez Boulevard and I-70 in Denver, CO. Elevated cadmium concentrations were also detected during recent sampling events. Due to analytical difficulty the results of the cadmium analysis are unreliable and will not be discussed further in this memorandum. The area of interest is bounded by the 56th Avenue on the North, 38th Avenue on the south, the South Platte River to the west, and Colorado Boulevard on the east. This screening level surface soil characterization effort conducted by EPA contractor URS Operating Services, Inc. under your oversight, included the collection of 3,550 surface (0-2") and depth (6-10") samples in approximately 1200 yards and measurement of these samples using X-ray fluorescence spectroscopy (XRF), inductively coupled plasma emission spectroscopy (ICP), and standard EPA quality assurance and quality control procedures. This memo will address only the surface (0-2") set of samples as this soil horizon is most likely to be contacted by children or adults presently living in the area. The results of this sampling effort and risk assessment are screening level and are subject to some variability and uncertainty. Variability in sample results may occur due to: 1) variation in sample location throughout the individual yard; 2) variation in particle size of the metals of concern in the soil; or 3) variation in the depth at which samples were collected. Uncertainty and variability in the risk assessment arises from several sources including: 1) uncertainty and variability regarding specific exposure situations of children and adults on the site (e.g. behavior, body weight, etc.); 2) uncertainty and variability regarding the absorption of metals from the soil matrix; and 3) a less than complete understanding of the mechanisms by which these metals cause disease. However, as explained in this memorandum, a subfraction of the soil measurements of lead and arsenic are very high and indicate the possibility of an imminent and substantial endangerment to public health. I, therefore, recommend that steps be taken to minimize direct exposure to individuals (especially children) who may come in contact with site-specific concentrations of surficial arsenic greater than approximately 400 parts per million (ppm). Additionally, steps should be taken to minimize risk to children by reducing exposure to soil concentrations of lead greater than approximately 2,000 ppm within the area of interest.

Data Evaluation:

A total of 3,550 soil samples were collected in the target area at a frequency of approximately 3 samples per residence during the months of March and April, 1998. The summary surface soil results of the sampling effort are presented below.

Arsenic concentration range (mg/kg or ppm)	Number of samples within range	Lead concentration range (mg/kg or ppm)	Number of samples within range
<70	2,162	<500	2,368
70-250	207	500-1,000	77
251-399	22	1,001-1,199	2
400-1000	38	1,200-1,500	2
>1000	7	>1,500	5

Samples were collected according to the EPA sampling plan for the site (UOS, 1998). Surface soils were collected into lead-free containers and sieved through a 10 mesh screen (approximately 2mm particle size) prior to analytical measurement by XRF or ICP. Sample locations were tracked using global positioning system (GPS) and entered into an interactive geographic database. Under the conditions of the sampling and analysis, a total of 46 properties had arsenic concentrations greater than or equal to 400 mg/kg and/or lead concentrations greater than or equal to 2,000 mg/kg. A total of 248 properties had arsenic concentrations ranging from 70 mg/kg to 399 mg/kg and/or lead concentrations ranging from 500 mg/kg 1,900 mg/kg. Four properties had lead concentrations greater than 2,000 ppm and no properties had lead concentrations greater than 4,000 mg/kg.

Complete physico-chemical characterization of the material which was collected is pertinent to understanding exposure and the risks posed by elevated metal concentrations in soil. For example, metals may be bound in a multitude of chemically and physically different matrices which might influence their solubility and bioavailability (fractional absorption across the gut). The particle size of the metal-bearing fraction of soil may also greatly influence the bioavailability and internal exposure to children or adults. Work is presently underway to fully characterize the samples collected as to particle size, organic carbon content, pH, chemical speciation, and matrix. In the absence of this information, EPA has reviewed recent studies conducted by the University of Colorado Department of Geology (CU) on soils in the vicinity of the present sampling effort (Drexler, 1998). For the protection of childhood health, and in the absence of direct characterization of the subject samples, it is plausible to assume that the physico-chemical characterization of soils in the immediate vicinity of the present sampling effort is likely to be representative of the samples collected by UOS.

The results of the CU study indicate that the frequency of occurrence of arsenic trioxide (As_2O_3) is on the order of 30% while the mass fraction of As_2O_3 in the vicinity soils is approximately 80%. There is a strong correlation (0.66) between As_2O_3 and arsenic antimony oxide (AsSbO) indicating the possibility that arsenic contamination in the area may be due to pyrometalurgical sources. As_2O_3 is highly oxidized. Because of this, arsenic is likely to be soluble and highly bioavailable to humans via the ingestion route of exposure. This bioavailability is enhanced by the relatively small particle size range characterized by CU scientists. The mean particle size for all arsenic species identified was 8 micrometers (µm). The mean particle size for the As_2O_3 phase was 9 µm with a range from 1-200 µm. This information is highly relevant to the risk evaluation of soils in the vicinity of Vasquez Blvd. And I-70 as it indicates that the arsenic is likely to be readily absorbed across the gastrointestinal tract and within a particle size (<250µm) expected to stick readily to hands, clothes, pet fur, and children's toys.

Exposure of Residents to Metals in Soil:

In order for exposure and risk to occur under current conditions, a complete exposure pathway must exist. Pathways of exposure to soil metals may be complex and multifaceted. For a complete exposure pathway to exist, there must be; 1) a source of contamination (metals in soil), 2) a release mechanism (e.g. bare soil areas or other possibility for release), 3) a transport of the soil contamination to a receptor (child or adult resident), and 4) an exposure route (ingestion, inhalation, or dermal absorption). Due to their atomic charge, metals are typically not well absorbed by the skin and this dermal route of exposure is usually insignificant in areas of soil contamination. Therefore, this route will not be discussed further in this memorandum. While exposure to metals in soil by inhalation can pose a significant threat in areas which are extremely dusty and human activity levels are high (such as in areas of active earth moving), this route of exposure is also far less significant in most residential exposure settings where there are not active smelter emissions. This is presently the case in the Vasquez and I-70 area and so this route of exposure will not be fully quantified in this memorandum.

In most cases where residential soil is contaminated with metals, the significant exposure route is through incidental ingestion of soil and dust. Soil and dust ingestion may be influenced by a variety of other environmental factors such as; 1) time spent outdoors, 2) amount of exposed bare soil, 3) proximity and condition of lead-based paints, 4) frequency of hand-to-mouth activity, 5) parental care, etc. Children and adults are typically exposed to soil and dust particle sizes less than approximately 250 micrometers in size as this particle size more readily adheres to hands, toys, and clothing. Sieving to this smaller particle size using a 60 mesh sieve may also reduce sample heterogeneity and slightly increase the measured metal concentration of the samples. EPA estimates that children may ingest an average of approximately 100 milligrams of soil and house dust per day (mg/day). This is due to common hand-to-mouth activity coupled with a tendency of children to be active at outdoor and indoor play. A reasonable upper bound estimate for childhood soil and dust ingestion used for this assessment is 200 mg/day. EPA assumes that adults may ingest 50 mg/day of soil and dust (EPA Exposure Factors Handbook).

Due to the chemical form of arsenic found in the neighboring community soils it is reasonable to assume that solubility of the material is relatively high and, as a consequence, fractional absorption of this material is correspondingly elevated. For the purpose of this assessment a range of absorption efficiencies of arsenic from soils of 50% to 80% relative to freely soluble arsenic in water will be used.

Toxicity of Arsenic and Lead:

Subchronic Arsenic Toxicity:

Most of the available peer reviewed literature which supports a scientific understanding of arsenic toxicity in humans is derived from cases of human exposure and resulting health effects following ingestion of arsenic contaminated water. Due to the likelihood of high bioavailability of the predominant arsenic species (As_2O_3), it is technically plausible (in the absence of data to the contrary) and protective of public health to assume that arsenic in these particular soils may be as toxiologically active as arsenic in several key toxicity studies.

Several studies address the question of short-term (from a few months up to five to seven years) exposure to arsenic. These studies were reviewed and discussed in detail by Region VIII toxicologists during September, 1995 (Benson, 1995). The nature of those discussions is reproduced herein.

The studies presented in this section represent those which describe non-cancer health effects related to arsenic exposure lasting from six months to 15 years. Assessment of short-term exposure to arsenic should only be undertaken in cases where chronic exposure is not likely or where steps to address chronic exposure to arsenic are expected. Health risk assessment which fully addresses the chronic aspects of arsenic exposure (carcinogenic effects) for these residential soils should be considered.

Tay and Seah (1975) provide a summary of 74 case histories from Singapore of arsenic poisoning attributed to the consumption of herbal preparations which contained arsenic sulfide or arsenic trioxide. Clinical findings in the individuals are consistent with symptoms known to be associated with arsenic intoxication. Ninety-two percent of the patients showed some form of cutaneous lesions (generalized hyperpigmentation, hyperkeratosis of palms and soles, "raindrop" depigmentation, palmar and plantar hyperhidrosis, multiple arsenical keratoses on trunk and limbs, mucous membrane lesions, diffuse alopecia, and Mee's lines in nails). The length of time the patients had ingested the herbal preparations varied from less than six months to approximately 15 years. 53% of the patients had ingested the preparations for one year or less and 84% of the patients had ingested the preparation for five years or less. The authors of this report estimated the dose of arsenic to be 3.1 milligrams per day (mg/day) in patients ingesting pills containing arsenic sulfide. The subchronic dose of arsenic necessary to cause an adverse effect is 0.06 - .2 mg/kg-day.

A series of papers in the peer reviewed literature discuss incidence of arsenic poisoning occurring in Antofagasta, Chile (Zaldivar, 1974; Zaldivar, 1977; Zaldivar and Guillier, 1977). The population was exposed to arsenic in drinking water and food. Of particular interest for derivation of a subchronic reference dose are the reports of skin lesions (leuko-melanoderma and/or hyperkeratosis of palms and soles, sometimes accompanied by scaling of the skin) in children. The children examined ranged in age from birth to 10 with a mean age of 1.7 years. Exposure time is assumed to be equal to the age of the child. Details of the examination of the children and the data used to derive the prevalence of disease in the population are not reported in the papers. The incidence of arsenic poisoning in the age group is reported to be 726.6 per 100,000. The calculated mean dose of arsenic for this age group is reported to be 0.063 mg/kg-day. This value was determined using the average measured concentration of arsenic in drinking water, the measured content of arsenic in a variety of foods, and the average body weight of the children. This publication documents adverse effects of arsenic observed following a subchronic dose of 0.06 mg/kg-day.

Borgono et al., (1980) describe the evaluation of 1277 school children (ten to 15 years of age) from different cities in the Antofagasta province of Chile. The study was conducted in 1977. The children were exposed to arsenic from the public water supply in the various communities and from food. The exposure time is not directly mentioned by the authors but is presumed to be equal to the age of the child. The results of the investigation are shown in the table below. The skin lesions observed included melanoderma, melanoleukoderma, hyperkeratosis of palms and soles, and peripheral vascular alterations (transient patches of cyanosis or white patches on the tongue, fingers, toes, and back of the hands and feet).

Location	Concentration of arsenic in drinking water (mg/l)	Incidence of Skin Lesions
Chuquicamata	0.08	4
Tocopilla	0.30	49
Maria Elena	0.30	54
Calama	0.30	19
Pedro De Valdivia	0.40	50

The authors of this study did not determine the amount of water or food-borne arsenic consumed by these individuals. Because the study was conducted in the same location as that reported by Zaldivar (1974 and 1977) and Zaldivar and Guillier (1977), it is reasonable to assume that the amount of arsenic ingested from drinking water and food are comparable. This study provides support for the conclusion that a subchronic dose of arsenic of 0.06 mg/kg-day is an effect level.

Huang et al., (1985) report an investigation of endemic arsenism in a plant in Kuitun area Xinjiang, China. The water supplying the plant came from a deep artesian well and contained 0.6 mg/l of arsenic. The well was first used in 1969. In 1982 the authors examined 336 individuals. One hundred and fifty people (44.6%) showed skin lesions characteristic of chronic arsenism. There was no control group. The lesions observed included dyspigmentation (diffuse brownish pigmented macules and spots mixed with depigmented areas) and keratosischiefly on the palms and soles. The exposure time in effected individuals ranged from six months to 12 years, but because no other symptoms presented with the cutaneous lesions, most patients failed to remember the exact time of onset of symptoms. Water consumption was not measured directly, but the authors stated that individuals drank more than two liters of water daily. The highest intake reported was eight liters daily. No information is provided on the arsenic content of the diet or on the body weight. Assuming an average consumption of water of five liters per day and a body weight of 50 kg, the dose of arsenic from drinking water is 0.06 mg/kg-day.

Two reports by Tseng (Tseng, 1968 and Tseng et al., 1977) were used to establish EPA's chronic reference dose. The lowest observed-effect level for skin lesions (hyperpigmentation and hyperkeratosis) was established at 0.014 mg/kg-day. Although not clearly reported, the data show a very strong increase in incidence of skin lesions with increasing time of exposure. See Tseng et al. (1968) Figures 5 and 6 and Tseng (1977) figure 6 and Tables 2, 4, and 6. These data strongly imply that an exposure duration of ten years or less at a dose of 0.014 mg/kg-day is a no-effect level for non-cancer endpoints. Taken together, these studies establish that adverse effects occur when people ingest for six months to 15 years a dose of 0.06 mg arsenic/kg-day. None of these studies adequately quantifies a no-observed-adverse-effect-level following subchronic exposure in people. Therefore, a subchronic lowest-adverse-effect-level of 0.06 mg/kg-day is coupled with and uncertainty factor of 10 for extrapolation to a subchronic no-observed-adverse-effect-level in humans.

$$Subchronic\ RfD = \frac{0.06\ \frac{mg}{kg\text{-}day}\ (effect\ level)}{10\ (uncertainty\ factor)} = 0.006\frac{mg}{kg\text{-}day}$$

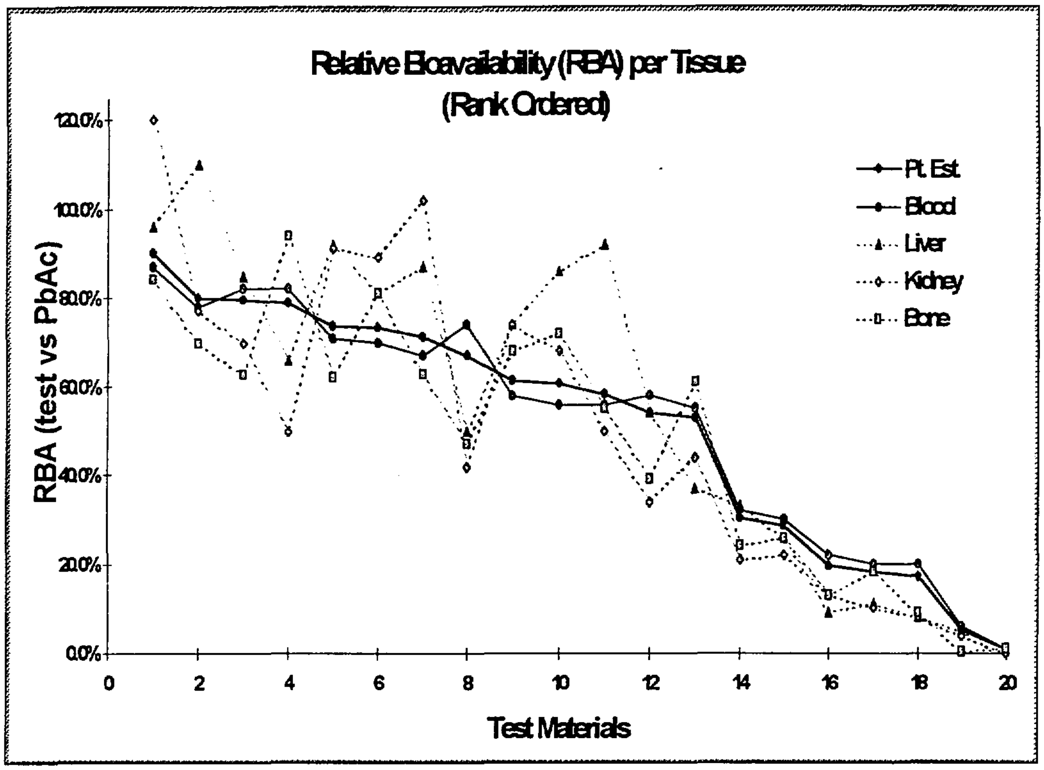
Lead:

Lead exposure in children is known to cause central nervous system effects resulting in learning disabilities, hearing impairment, and behavioral difficulties (Needleman, 1990). Children are particularly susceptable to the effects of lead due to: 1) the tendency for children less than the age of 7 to absorb lead much more efficiently than adults; 2) the particular susceptibility of the developing brain to the toxicological effects of lead, and 3) the tendency for children to be more highly exposed to possible sources of lead such as dust, soil and paint due to exploratory behavior. These effects have been demonstrated in large epidemiological studies to occur at blood lead levels of 10 micrograms per deciliter of blood (10 μg/dL). Needleman (1990) demonstrated the tendency for lead toxicity in children to persist long after exposure ends. It is not known how long exposure must occur for persistent effects to appear. However, seasonal exposure to environmental lead is sufficient to bring blood lead concentrations to semi-steady state as determined by pharmacokinetic studies in animals.

Adults in a residential setting are generally less exposed to the effects of lead due to lower absorption rates and generally less exposure. However, lead is known to redily cross the placenta with a transfer efficiency to the developing fetus of approximately 90%. Thus, pregnant women and women of child-bearing age are of concern in an environment conducive to excessive lead exposure. Typically, steps which are taken to reduce exposure of children to lead are also effective for reducing or eliminating adult exposure.

The absorption of lead from soils associated with the metal extraction industries is highly variable. Region VIII has tested the gastrointestinal absorption of several lead contaminated soils using an immature swine model as a surrogate for young children. The results of that investigation are summarized in the figure below. This study measured the relative bioavailability of lead in soils compared to the bioavailability of freely soluble lead acetate in water. The preliminary results indicate that lead in mine waste is highly variable relative to highly soluble lead acetate (Casteel et al, 1998). The range of relative bioavailabilities (RBA) measured in the study is from approximately 6% to approximately 86% compared with absorption of soluble lead. Most of the soil lead identified in communities adjacent to the Vasquez Blvd. and I-70 area is in the form of a relatively soluble arsenic lead oxide (AsPbO) with a mean particle size diameter of 4μm (range 1-100μm). AsPbO of this small particle size would be expected to have relatively high bioavailability. It is also likely that some fraction of the lead in North Denver soils derives from lead-based paint.

EPA employs an Integrated Uptake Biokinetic Model (IEUBK model) for assessing exposure to children in residential settings. This computer model employs estimation of the absorption, distribution, and excretion of lead in children to predict blood lead concentrations following exposure to environmental lead. When available, appropriately collected human biomonitoring information (blood lead measurements) is useful for determination of recent environmental exposure. Information regarding multiple sources of exposure such as lead in water or paint aid in the understanding of risk related to lead absorption by children. Using standard default exposure assumptions, the IEUBK model predicts an approximate 50% probability of children having blood leads greater than the Agency recommended limit of 10 µg/dL when soil lead concentrations exceed 2,000 ppm.



<u>**Risk Characterization:**</u>

Arsenic:

A range of risk-based exposure levels for short term exposure (6 months to 15 years) of children (2-3 years old) to arsenic can be established using the subchonic (non-cancer) toxicity information presented above coupled with site-specific and Agency default assumptions about the dose which might be ingested following exposure to soil and housedust in the neighborhoods of interest. Using a range of childhood body weights for children between the ages of 2 years and 6 years (11-16 kg) and a range of plausible absorption fractions for oxidized arsenic compounds (50 to 80%[1]), a corresponding range of risk-based soil levels can be established. Equation 2 and 3 were used to estimate risk-based exposure levels of concern for short term (6 months to 10 years) exposure to arsenic in residential soils.

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[1] Absorption (bioavailability) of soil arsenic has been measured in experimental animals. USEPA Region 8 toxicologists have recently released the results of a series of studies on the absorption of soil arsenic (Henningsen et al, 1998). The available data indicates that soil arsenic is less bioavailable than arsenic in water. However, estimates of soil arsenic absorption range from approximately 20% to as high as 100% relative to freely soluble arsenic.

Where:

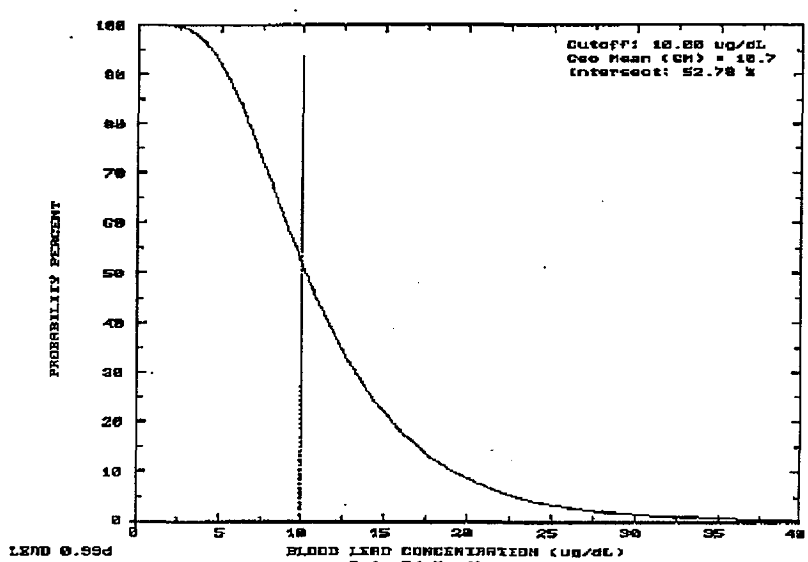
$$\text{Exposure Level} = \frac{\text{subchronic RfD } \left(\frac{mg}{kg\text{-}day}\right) \times \text{Body Weight } (kg)}{\text{Soil Ingestion Rate } \left(\frac{gms}{day}\right) \times \text{Absorbed Fraction}} \times \frac{1000\ ug}{1\ mg} \quad \textbf{(2)}$$

Subchronic RfD = 0.006 mg/kg-day
Body Weight = 11-15 kg (child)
Soil Ingestion Rate = 0.2 grams/day
Absorbed fraction = 0.5 - 0.8 demensionless

$$\text{Exposure Level} = (412\text{-}900)\ \frac{mg}{kg} = \frac{0.006\ \left(\frac{mg}{kg\text{-}day}\right) \times (11 - 16)\ (kg)}{0.2\ \left(\frac{gms}{day}\right) \times (0.5 - 0.8)} \times \frac{1000\ ug}{1\ mg} \quad \textbf{(3)}$$

The range of risk-based exposure levels of concern is from 412 mg/kg (ppm) to 900 mg/kg arsenic in soil. This range of risk-based exposures is applicable only for short-term, interim actions which might be taken to reduce or eliminate exposure to arsenic in soil. Due to the carcinogenic potential of arsenic, steps should be taken to assess the possibility of longer-term exposures above risk-based levels of concern.

To assure adequate protection of public health, it is recommended that any actions taken to reduce exposure to soil arsenic in this neighborhood focus on the lower end of this soil range. The rationale for providing a significant margin of protection is three fold: 1) As discussed previously, recently collected evidence available from near-by the site indicates that the arsenic bearing material may be of fine particle size and is likely to be very soluble and bioavailable. Efforts to improve our understanding of arsenic absorption on this site would be both expensive, technically complex, and would require significant time; 2) while the State of Colorado is presently conducting protective biomonitoring in neighboring communities, there is no similar program in place to monitor actual exposure in the vicinity of Vasquez Blvd. and I-70; and 3) while there is an interest in pursuing longer-term clean-up options for the site, there is presently no established activity underway to implement longer-term options.



Lead:

Using standard default exposure assumptions, EPA's IEUBK model predicts an approximate 50% probability that children's (0-84 months) blood lead will exceed 10 µg/dL when soil lead concentrations exceed 2000 ppm. This predicted blood lead probability is considerably greater than the EPA goal of not more than a 5% probability of a childhood blood level greater than 10 µg/dL. Medical monitoring for childhood blood lead has proceeded in the general vicinity of the Globeville smelter which is north and east of the neighborhoods of interest for this memorandum. A baseline study conducted in 1994 prior to soil remediation or community education. The results indicate relatively low blood lead concentration in children between the ages of 0-6 years. A summary of human biomonitoring conducted in the baseline monitoring program by the State of Colorado Department of Public Health and Environment in cooperation with the Agency for Toxic Substances and Disease Registry is presented in the table below. The data do not indicate that childhood lead exposure was excessive during the time that the samples were taken. This discrepancy between modeled and measured blood lead cannot be resolved with available data but is often noted in areas contaminated by mining and smelting wastes. In order to assure protection of childhood health steps should be taken to minimize exposures to soil lead concentrations greater than 2000 ppm. Additional exposure-based sampling would better define the nature of human exposure on the site and may better define the discrepancy between measured and modeled blood lead concentrations.

	number of individuals	average blood lead (µg/dL)	number of children >10µg/dL
Blood lead (0-6 years)	127	3.4	7 (5.5%)
Blood lead (>6 years)	799	2.9	0

Summary:

Recently collected surface soil data in the vicinity of Vasquez Blvd. and I-70 indicate the presence of elevated levels of arsenic and, to a lesser extent, lead. Levels of these levels exceed concentrations which may pose an imminent and substantial endangerment to human health following short term (6 months to 10 years) exposure. The primary exposure pathway is incidental ingestion of soil and dust by children in areas with poor ground cover or stressed vegetation where children may play. Steps should be taken to minimize exposure of children to arsenic in surface soils where levels are approximately 400 parts per million or greater. Lead exposure to surface soils greater than 2000 ppm are also of concern for children. Steps should be taken to minimize exposure of children to lead in surface soils where levels are approximately 2000ppm or greater.

cc: D. Skie
B. Murray
M. Dodson
B. LaVelle

References:

Benson, R., (1995) Memorandum from R. Benson to Christopher Weis, Subchronic Reference Dose for Arsenic. September 12, 1995.

Drexler, J. (1998) A study on the source of anomalous arsenic concentrations in soils from the Globeville community, Denver, CO June 9, 1998.

EPA (1996) Exposure Factors Handbook EPA/600/P-95/002Ba.

Henningsen, G., Weis, CP, Hoffman, E., Brattin, W., Christensen, S. (1998) Differential Bioavailability of lead mixtures from 20 different soil matrices at Superfund mining sites. *The Toxicologist.*

Huang, Y., Quian, X., Wang, G., Xiao, B., Ren, D., Feng, Z., Wu, J., Xu, R., and Zhang, F., (1985) Endemic chronic arsenism in Xinjiang. *Chinese Medical Journal* 98(3): 219-222.

Needlelman, H; Schell, A.;Bellenger, D.; Leviton, A.; Allred, E. (1990) The long-term effects of exposure to low doses of lead in childhood. *New England Journal of Medicine*, 322;83-88.

Rabinowitz, M.; Kopple, J.; Wetherill, G. (1980) Effect of food intake and fasting on gastrointestinal lead absorption in humans. Am. J. Clin. *Nutrition.* 33;1784-1788

Tay, C.H., and Seah, C. (1975) Arsenic poisoning from anti-asthmatic herbal preparations. *Med. J. Aust.* 2:424-428.

Tseng, W.P., 1997. Effects and dose-response relationships of skin cancer and blackfoot disease with arsenic. *Environ. Health Perspect.* 19:109-119.

Tseng, W.P., Chu, H.M., How, S.W., Fong, J.M., Lin, C.S., and Yeh, S. 1968. Prevalence of skin cancer in an endemic area of chronic arsenicism in Taiwan. *J. Natl. Cancer Inst.* 40:453-463.

URS Operating Services (UOS). 1998. Final Sampling and Analysis Plan. March 19, 1998.
Zaldivar, R., (1974) Arsenic Contamination of drinking water and food-stuffs causing endemic chronic poisoning. *Beitr. Path. Bd.* 151:384-400.

Zaldivar, R., (1977) Ecological investigations on arsenic dietary intake and endemic chronic poisoning in man: dose-response curve. *Zbl. Bakt. Hyg.*, I Abt. Org. B 164:481-484.

Zaldivar,R., and Guillier, A., (1977) Environmental and clinical investigations on endemic chronic arsenic poisoning in infants and children. *Zbl. Bakt. Hyg., I. Abt. Orig. B.* 165:226-234.

Attachment 2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
999 18TH STREET - SUITE 500
DENVER, CO 80202-2466

Ref: ENF-L

August 17, 1998

By Facsimile

Ms. Frances Hartog
Assistant Attorney General
Office of the Attorney General
State of Colorado
1525 Sherman St., 5th Floor
Denver, CO 80203

Dear Frances:

I have reviewed the ARARs the State of Colorado submitted to me for the removal action at what we are now calling the Vasquez-I70 site (the "Site"). As I have previously indicated to you in a phone conversation, the list does not distinguish between what the State believes to be applicable, versus what the State believes to be appropriate and relevant. Thus, I have had to draw my own conclusions about state law and regulations. In addition, the list appears to be a generic one used without much consideration as to how it might apply to the Site.

As you are aware, the Site's boundaries are as yet undefined. The remedial investigation/feasibility study will determine the nature and extent of contamination, which will in part define such boundaries. Given the current uncertainty related to boundaries, I have chosen to treat each residential cleanup as its own site for ARARs purposes. Thus, when reviewing the State's submission, I was looking for those regulations which would be meaningful for activities that actually occur within the boundaries of each individual residential property. This initial cut removed all of the hazardous materials and transportation regulations as ARARs, because no activities will occur within the residential property that are covered by such regulations. In addition, the State never provided the documents I requested indicating whether the State enacted the 1990 rulemaking on formerly Bevil excluded wastes, thus I would not be able to determine if the requirements were applicable.

A review of the State's regulations on air quality shows that the majority of them are meant to apply to stationary sources, not the small, short duration construction activities that are going to occur during this removal action. The only regulatory requirement which seemed to be applicable to the activities being performed was Regulation 1, 5 CCR 1001-3. This regulation applies to the control of fugitive particulate emissions, but is only applicable in a nonattainment area where the construction activities involve parcels greater than one acre. Thus, I have relayed to the technical team that this requirement may be relevant and appropriate for the removal action. Ultimately, the delegated decision-maker must make the decision on ARARs. I will provide that decision-maker with the State's submission, so that s/he can determine if any other State-identified ARARs should be used.

If EPA does perform a remedial investigation/feasibility study for the Site, the State will be requested to provide a much more detailed analysis of potential ARARs. I would expect that together, the State and EPA will have many more ARARs that would be appropriate for that larger remedial action.

Sincerely,

Matt Cohn

Matthew Cohn
Legal Enforcement Program

cc: Peter Stevenson
Bonita Lavelle

Vasquez/I-70 Removal ARARs

Due to the limited timeframe, this listing may be incomplete. We assume that EPA will identify Federal ARARs so many of these regulations have not been identified by the state. The state may identify additional ARARs or provide additional detail as time progresses.

Chemical Specific ARARs	
Colorado Hazardous Waste Management Regulations, 6 CCR 1007-3, part 261, Identification of Hazardous Waste	Excavated materials expected to meet TCLP characteristics must be characterized to determine if hazardous waste. If TCLP, materials must be handled and disposed of in accordance with hazardous waste requirements. no proof of promulgat standar
Colorado Air Quality Control Regulations, 5 CCR 1001-14 (ambient air standard for Total Suspended Particulate Matter; primary standard: 75 u/m3 annual geometric mean, 260 ug/m3 24-hr standard; secondary standard 60 ug/m3 annual geometric mean, 150 ug/m3 24-hr standard.	not for specific sources
National Ambient Air Quality Standards 40 C.F.R. part 50 including PM10, PM2.5	ditto
? Colorado Air Quality Control Regulations, 5 CCR 1001-10, Regulation 8 (ambient air standard for lead; monthly average concentration must be less than 1.5 ug/m3.)	Stationary source
Action-Specific ARARs	
Colorado Solid and Hazardous Waste Disposal Sites and Facilities Regulations, 6 CCR 1007-2, (solid waste provisions.)	Must be achieved for disposal of any solid waste materials.
Colorado Hazardous Waste Management Regulations, 6 CCR 1007-3, part 262 (standards applicable to generators of hazardous waste.)	Must be achieved for any hazardous wastes generated.
Colorado Hazardous Waste Management Regulations, 6 CCR 1007-3, part 263 (standards applicable to transporters of hazardous waste.)	Must be achieved for any hazardous wastes transported.
Colorado Hazardous Waste Management Regulations, 6 CCR 1007-3, part 264 (standards applicable to owners and operators of treatment, storage and disposal facilities.)	Must be achieved for any hazardous wastes stored, treated, or disposed.
Colorado Rules and Regulations Concerning Transportation of Hazardous Materials, 8 CCR 1507.	Must be achieved for any hazardous wastes transported.

Federal Hazardous Materials Transportation Regulations, 49 C.F.R., parts 107, 171-177	Must be achieved for any hazardous wastes transported.
Colorado Air Quality Control Regulations, 5 CCR 1001-2-1001-14. (Common provision regulations, implementing regulations. Establishes standards for controlling fugitive particulate emissions, odors, and air toxics.)	Must be achieved for control of emissions, odors, and toxics from construction activities. ?
A Colorado Air Quality Control Regulations, 5 CCR 1001-3, Regulation 1 (establishes emission control regulations and opacity standards for particulate matter, requires minimization of fugitive particulate emissions from construction activities, requires submission of fugitive particulate emission control plan.)	Must be achieved for control of dust, emissions from construction activities. RTA
Colorado Noise Abatement Statute, 25-12-101 to 103, C.R.S.	Must be achieved for construction activities. HvL?
Colorado Air Quality Control Regulations, 5 CCR 1001-4, Regulation 2. (Establishes odor emission regulations. Systems to be designed to provide odor-free operation.)	Must be achieved for construction activities. where is odor likely from this operation?
B Colorado Air Quality Control Regulations, 5 CCR 1001-5, Regulation 3. (Requires analysis of air pollution impacts prior to start of project; Air Pollution Emission Notice (APEN) to be filed; source cannot cause an exceedance in any attainment area of any National Ambient Air Quality standard; source cannot interfere with attainment and maintenance of any state ambient air quality standard; source to undergo review procedure which estimates public health impacts from toxic pollutants.)	Must be achieved for construction activities, except for particulate matter standards which are routinely exceeded throughout the Denver metropolitan area. See notes for Part A not ARAR Part B - only applies to stationary sources
Colorado Air Quality Control Regulations, 5 CCR 1001-10, Regulation 8. (Sets forth emission control requirements for hazardous air pollutants, including lead.)	Must be achieved for construction activities applies to stationary sources not RTA either
Criteria for municipal solid waste landfills. 56 F.$. 59978, October 9, 1991 (codified at 40 C.F.R. 258.)	Must be achieved when managing solid wastes.

Attachment 3

ENFORCEMENT CONFIDENTIAL

Enforcement Addendum
North Denver Residential Soils (SSID #9R)

(b) (7)(A)

[redacted]

#1751

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
999 18th STREET - SUITE 500
DENVER, COLORADO 80202-2466

SEP 16 1998

Ref: 8EPR-ER

CONFIDENTIAL

ACTION MEMORANDUM

SUBJECT: Request for a Time-Critical Removal Action at the Vasquez Boulevard and I-70 (aka North Denver Residential Soils) Site, City and County of Denver, Colorado.

FROM: Pete Stevenson, On-Scene Coordinator
Emergency Response Team

THROUGH: Steve Hawthorn, Supervisor
Emergency Response Unit

Douglas M. Skie, Director
Preparedness, Assessment & Emergency Response Program

TO: Max Dodson, Assistant Regional Administrator
Office of Ecosystems Protection & Remediation

Site ID#: 9R
Category of Removal: Time-Critical, Fund-Lead

I. PURPOSE

The Purpose of this Action Memorandum is to request and document approval for the proposed Removal Action described herein for portions of residential neighborhoods in the vicinity of Vasquez Boulevard and I-70, City and County of Denver, Colorado (the Site). The conditions at this Site meet the emergency criteria for a Removal Action. The Removal Action will involve excavation of soils containing elevated levels of lead and arsenic from residential properties at the Site.

II. SITE CONDITIONS AND BACKGROUND

Sampling conducted by the Colorado Department of Public Health and Environment (CDPHE) and the U.S. Environmental Protection Agency (EPA) in 1997/1998 has identified elevated levels of lead and arsenic in residential soils in the communities of Elyria and Swansea in Denver. Sources of contamination appear to be related primarily to historic smelting activities that occurred in the Denver area from the 1870s to the 1950s. The contaminated soils in residential areas at the Site are the subject of this Action Memorandum.

A. Site Description

1. Removal site evaluation

In 1997 CDPHE conducted limited sampling at the Vasquez Boulevard and I-70 site. Of 25 soil samples, six contained lead (Pb) and/or arsenic (As) above screening levels (500 ppm Pb and/or 70 ppm As).

In April of 1998, EPA sampled approximately 1200 residential properties, collecting 3550 samples. Properties with As $\geq$70 mg/kg and $\leq$399 mg/kg and with Pb between 500 and 1999 mg/kg numbered 248. Properties greater than 400 mg/kg As and greater than 2000 mg/kg Pb numbered 46. Of these 46, seven contained the higher values at a depth of 6", with surface soil being less contaminated. These properties do not pose an immediate threat and will be left for remedial action. One property is a parking lot, and one consists of an old house with flaking paint and no signs of children (EPA will alert the proper authorities regarding the paint issue). These remaining 37 properties, and others found in the Phase II sampling, have undergone more extensive sampling to better define the areas of contamination. Results indicate that a total of 21 properties remain as Removal Action candidates.

2. Physical Location

The Site is located in the northwest part of Denver and generally is bounded by the South Platte River on the West, Colorado Boulevard on the East, 38th Avenue on the South, and 52nd Avenue on the North. As of the date of this writing, a second phase of sampling has been conducted south to 35th Avenue. Another small area South of I-70 and West of I-25 - bordered by Fox on the West and Cahita Court on the East - has also been sampled in this second phase. Results have not yet been validated and released from this second phase.

3. Site Characteristics

The Site area was settled in 1851, four years after the first pioneers entered the valley. Approximately 5700 people currently live in Elyria and Swansea, the predominant neighborhoods in the Site area. Youth under 18 comprise 36% of the residents (twice the average of the City of Denver).

Soon after development of the area, it was presumably contaminated by wastes containing lead and arsenic from smelting operations in the area. At least three smelters operated in the area in the late 1800s. These smelters reportedly deposited wastes within or adjacent to the Site.

4. Release or threatened release into the environment of a hazardous substance, or pollutant or contaminant.

Arsenic and, to a lesser degree, lead have been identified at the Site as the contaminants of concern. Arsenic and lead are hazardous substances, as defined by Section 101 (14) of CERCLA. These hazardous substances may have been released into the residential soils by historic smelting activities and spread through the Community by aerial deposition. At least 21 properties contain arsenic and lead at levels of concern to the Removal Program.

Because arsenic contamination is found in unsodded areas that are used for recreation, there is also a potential for contaminated soil to be wind-blown and dust-sized particles to be transported by wind and human activities into additional yards and into homes. There are an estimated 6000 cubic yards of soil contaminated above the selected Removal Program health protective action level of 2000 ppm lead and/or 450 ppm arsenic.

5. NPL Status

The Site will be evaluated for possible NPL listing.

B. <u>Other Actions to Date</u>

1. Previous Actions

The only previous actions pertaining to this Site have related to the sampling of soils and sediments, and these activities have been discussed in previous sections of this document.

2. Current Actions

The proposed action described in this Action Memorandum will address contamination in residential yards. Removal of the soils, contaminated by unacceptable levels of arsenic and lead, is consistent with previously implemented actions in the Region.

C. State and Local Authorities' Roles

The State and local agencies are actively involved in EPA's activities at the Site. Many of the Site technical issues are discussed at the Working Group meetings which include representatives from EPA, CDPHE, Denver City and County Environmental Health Departments, and neighborhood groups.

III. THREATS TO PUBLIC HEALTH OR WELFARE, THE ENVIRONMENT, AND STATUTORY AND REGULATORY AUTHORITIES

A. Threats to Public Health or Welfare

Conditions at the Site present an imminent and substantial endangerment to human health and the environment and meet the criteria for initiating a Removal Action under 40 C.F.R. Section 300.415 (b) (2) of the National Contingency Plan (NCP). The following factors from Section 300.415 (b) (2) of the NCP form the basis for EPA's determination of the threat presented, and the appropriate action to be taken:

(i) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants, and

(iv) High levels of hazardous substances or pollutants and contaminants in soils largely at or near the surface, that may migrate.

There is a significant potential for continued exposure to nearby human populations with at least 21 properties, where children or pregnant women are present, which contain average Pb concentrations greater than 2000 ppm and/or As averages greater than 450 ppm in the upper 2 inches. EPA's toxicologist has reviewed the data and determined action levels for the Removal Action. Threats to human health and selection of health protection action levels are described in detail in the endangerment assessment.

B. Threats to the Environment

The primary threat identified is exposure to human populations.

IV. ENDANGERMENT DETERMINATION

The actual or threatened releases of hazardous substances from this Site, if not addressed by implementing the response action selected in this Action Memorandum, may present an imminent and substantial endangerment to public health or welfare or the environment. (See the attached memorandum dated July 24, 1998, from EPA Region VIII Toxicologist Christopher P. Weis, Ph.D., DABT, regarding "Exposure to Elevated Levels of Arsenic and Lead in Residential Soils" - Attachment 1).

V. PROPOSED ACTIONS AND ESTIMATED COSTS

A. Proposed Action

1. Proposed action description

The following represents factors considered in determining whether properties within the community will be included within EPA's time critical removal action. These criteria were developed with input from EPA toxicologists, technical staff, and CDPHE/Denver personnel. They are based on the need to provide immediate reduction in exposure to arsenic/lead contaminated soil. These factors are generally considered on a zone-by-zone basis to establish whether an individual zone should be addressed to safeguard the overall residential yard for a young child. Both current and potential future exposures must be considered in applying the criteria.

Currently 21 properties have tentatively been identified as candidates for this Removal Action. These and additional properties will be addressed as follow-up sampling results indicate that levels exceed the action levels and other criteria discussed above. Additional properties may be found that qualify for Removal. Further, soil on identified properties that do not exceed the Removal Action level may be removed for economic reasons if they are at or near the action level.

Zones on properties will generally be included in the Removal Action if the average surface soil concentration (top 2") exceeds 2000 mg/kg of lead or 450 mg/kg of arsenic. In these instances soil will be removed to a 12" depth - for vegetable gardens soil will be removed to 18". This strategy provides two layers of protection. A protective barrier of at least twelve inches of clean material will be established for all zones. Secondly, if in the future this barrier is disrupted, average surface concentrations will remain below a health protective level.

The following describes removal options designed to reduce exposure to elevated arsenic concentrations. In most instances removal and off-site disposal of contaminated soils above the action level will be the preferred action. This option provides the greatest level of certainty with respect to risk reduction. In certain instances other health protective options will be considered on a property-by-property basis.

a. The depth of all removals will be 12". This depth provides an adequate barrier between soil contamination, if any, and children. In vegetable gardens removal of 18" will provide adequate protection under typical day-to-day exposure scenarios.

b. Capping with 12" soil or 4" asphalt may be considered for areas meeting all the following conditions: (1) a removal is not feasible (a lot with many large trees that the homeowner does not want removed); (2) there is relative certainty that the land use will not change in the short term (e.g. the cap will not be disturbed); and (3) drainage will not be adversely affected.

c. Mixing through tilling may be considered for areas that (1) are marginally above the action level in the first 0-6" but below the action level at depth; and (2) are relatively large and unsodded such that a considerable cost savings would be realized. This option may also include sampling prior to tilling to confirm that deeper levels are well below the action level. This option will include post tilling sampling to assure that the desired reduction in average contaminant level has occurred. If this option is chosen at any residence, a re-evaluation of ARARs will be undertaken.

This Removal Action includes the following specific activities:

a. Contaminated soils will be removed, capped or tilled according to the above criteria.

b. Individual residences where soil is removed will be backfilled with clean soil and top soil to the original grade and landscaped with sod.

c. Structures and fencing on the properties will be left in place or returned to their original locations if removal is necessary. If fencing cannot be reused, it will be replaced.

d. Contaminated soils may be consolidated at a staging area and secured in storage prior to disposal.

e. Existing Shrubs and/or Bushes(defined as low, densely branched plants that impede soil removal): Removal and replacement with the same species, standard nursery stock, and number of plants.

f. Existing Perennial Plants: Removal and replacement with the same (to the extent possible) or similar species, approximate size, and number of plants.

g. Annual Plants: Removal with no replacement.

h. Existing Sprinkler Systems: If the existing system impedes soil removal or will not function after barrier soil is placed, removal and replacement with the same or similar system.

i. Existing Concrete, Asphalt, Brick Stone, or Tile Surfacing (sidewalks, driveways, parking,lots, pads): Remain in place and excavate around unless the existing surfacing has been damaged in the past to the extent that soils exceeding the action levels are exposed. If soils exceeding the action levels have been exposed, remove and replace the surfacing with equivalent materials, if necessary to prevent exposure. The original materials may also be used if soil is removed before replacement.

j. Existing Landscape Covers and Borders: Removal and replacement with equivalent materials in areas requiring remediation. The original materials may also be used if soil is removed before replacement and materials are not damaged during removal.

k. Outdoor Animals: Temporary relocation during remediation of individual properties located in areas requiring remediation.

l. Movable Buildings and Sheds: Temporary relocation during remediation, if remediation is necessary at that location.

m. <u>Existing Vegetable Gardens Exceeding Action Levels:</u> Removal of a maximum of 18 inches of soil; replacement with a minimum of, but not necessarily more than, 18 inches of suitable vegetable garden soil with characteristics acceptable to EPA. Suitable vegetable garden soil will consist of clayey or sandy loam soils having a specified minimum percentage of organic matter. Suitable grades and ground cover will be restored.

n. <u>Prevention of Indoor Dust:</u> Dust suppression measures will be utilized during Removal. If necessary, other measures, such as sealing of doors and windows with plastic, will be taken during remediation of individual properties. If necessary, portable air cooling devices will be offered to residents during this time period.

o. <u>Existing Decks:</u> Remain in place and excavate beneath and around as needed unless the existing deck impedes soil removal. Options: should existing deck impede soil removal, include removal of existing deck and replace with an equal deck or utilize "shot crete" under the deck.

Owners will be asked for permission to remediate their residential areas. Detailed plans will be developed for the properties which are undergoing remediation, and owners will be provided copies and an opportunity to discuss the plans. The removal schedule will be provided to the owner; and after the removal, replacement of sod, etc., each owner will review the action with the OSC and discuss any future activities.

2. Contribution to remedial performance

The Removal Action proposed by EPA for this Site is consistent with the long-term plans of the Remedial Program.

3. Description of alternative technologies

As described in Section VI, a flexible approach has been crafted for this Removal Action, based on site-specific circumstances. Alternative approaches, such as tilling, will be implemented where appropriate. No other alternative technologies are practical or effective to achieve the Removal Action objectives.

4. Engineering Evaluation/Cost Analysis (EE/CA)

An engineering evaluation/cost assessment is not required for this action. No alternative technologies are practicable or effective.

5. ARARs

This Removal Action will attain, to the extent practicable, considering the exigencies of the situation, ARARs of Federal OSHA and environmental, or more stringent state environmental or facility siting laws. (See Attachment 2 for further information.)

6. Project Schedule

The construction portion of this Removal Action is scheduled to begin in September of 1998 and is planned to be completed by December of 1998. Monitoring of landscape restoration will continue into the Spring of 1999. This work schedule may be extended if the additional sampling reveals that more properties are contaminated above the action level.

B. Estimated Costs

Extramural Costs:

Regional Allowance Costs	
ERRS	$590,000
Other Extramural Costs Not Funded From The Regional Allowance:	
START	$100,000
20% Extramural Costs Contingency	$140,000
TOTAL EXTRAMURAL COSTS	**$830,000**

Intramural Costs:

Intramural Direct Costs	$ 50,000
Intramural Indirect Costs	$105,000
TOTAL INTRAMURAL COSTS	**$155,000**

TOTAL REMOVAL PROJECT CEILING **$985,000**

VI. EXPECTED CHANGE IN THE SITUATION SHOULD ACTION BE DELAYED OR NOT TAKEN

If no removal action is taken at the Site or if the action is delayed, the residents in the area will continue to be exposed to high levels of lead and arsenic. The endangerment assessment indicates that children have an increased chance of developing blood lead levels or arsenic toxicity that may cause irreversible health effects. The potential for migration of the contaminants exists in the event of runoff from rainstorm/flooding or through wind dispersion. These processes could spread contamination into previously uncontaminated areas nearby.

VII. OUTSTANDING POLICY ISSUES

As of the date of this Action Memorandum, EPA, CDPHE, and the City & County of Denver intend to pursue a long-term Remedial Action. This Removal Action only addresses those properties with high levels of contamination at the surface. The Remedial Program is already active and dealing with the long-term policy issues.

VIII. ENFORCEMENT

A confidential Enforcement Memorandum is included - Attachment 3.

IX. RECOMMENDATION

This decision document represents the selected Removal Action for the Vasquez Boulevard and I-70 Site, City and County of Denver, Colorado, developed in accordance with CERCLA, as amended, and is consistent with the NCP. This decision is based on the administrative record for the site.

Conditions at the Site meet the NCP §300.415 (b) (2) criteria for a removal, and I recommend your approval of the proposed Removal Action. The total project ceiling will be $985,000. Of this amount, an estimated $830,000 comes from the Regional removal allowance.

Approve: Max H Dodson

Date: 9/16/98

Max H. Dodson

Disapprove:________________________

Date:__________

Max H. Dodson
Assistant Regional Administrator
Office of Ecosystems Protection and Remediation

Attachments:

Attachment 1:	Memorandum from EPA Toxicologist
Attachment 2:	ARARs
Attachment 3:	Enforcement Memorandum

Attachment 1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII (8EPR-PS)
999 18th STREET - SUITE 500
DENVER, COLORADO 80202-2466

Region VIII

JUL 27 1998

MEMORANDUM

SUBJECT: Exposure to elevated levels of arsenic and lead in residential soils in the vicinity of Vasquez Blvd. and I-70 may pose an imminent and substantial endangerment to public health.

FROM: Christopher P. Weis, Ph.D., DABT.
Regional Toxicologist

TO: Peter Stevenson
On Scene Coordinator

This memorandum addresses recently characterized metal contamination from lead and arsenic in residential surface soils in specific neighborhoods in the vicinity of Vasquez Boulevard and I-70 in Denver, CO. Elevated cadmium concentrations were also detected during recent sampling events. Due to analytical difficulty the results of the cadmium analysis are unreliable and will not be discussed further in this memorandum. The area of interest is bounded by the 56th Avenue on the North, 38th Avenue on the south, the South Platte River to the west, and Colorado Boulevard on the east. This screening level surface soil characterization effort conducted by EPA contractor URS Operating Services, Inc. under your oversight, included the collection of 3,550 surface (0-2") and depth (6-10") samples in approximately 1200 yards and measurement of these samples using X-ray fluorescence spectroscopy (XRF), inductively coupled plasma emission spectroscopy (ICP), and standard EPA quality assurance and quality control procedures. This memo will address only the surface (0-2") set of samples as this soil horizon is most likely to be contacted by children or adults presently living in the area. The results of this sampling effort and risk assessment are screening level and are subject to some variability and uncertainty. Variability in sample results may occur due to: 1) variation in sample location throughout the individual yard; 2) variation in particle size of the metals of concern in the soil; or 3) variation in the depth at which samples were collected. Uncertainty and variability in the risk assessment arises from several sources including: 1) uncertainty and variability regarding specific exposure situations of children and adults on the site (e.g. behavior, body weight, etc.); 2) uncertainty and variability regarding the absorption of metals from the soil matrix; and 3) a less than complete understanding of the mechanisms by which these metals cause disease. However, as explained in this memorandum, a subfraction of the soil measurements of lead and arsenic are very high and indicate the possibility of an imminent and substantial endangerment to public health. I, therefore, recommend that steps be taken to minimize direct exposure to individuals (especially children) who may come in contact with site-specific concentrations of surficial arsenic greater than approximately 400 parts per million (ppm). Additionally, steps should be taken to minimize risk to children by reducing exposure to soil concentrations of lead greater than approximately 2,000 ppm within the area of interest.

Data Evaluation:

A total of 3,550 soil samples were collected in the target area at a frequency of approximately 3 samples per residence during the months of March and April, 1998. The summary surface soil results of the sampling effort are presented below.

Arsenic concentration range (mg/kg or ppm)	Number of samples within range	Lead concentration range (mg/kg or ppm)	Number of samples within range
<70	2,162	<500	2,368
70-250	207	500-1,000	77
251-399	22	1,001-1,199	2
400-1000	38	1,200-1,500	2
>1000	7	>1,500	5

Samples were collected according to the EPA sampling plan for the site (UOS, 1998). Surface soils were collected into lead-free containers and sieved through a 10 mesh screen (approximately 2mm particle size) prior to analytical measurement by XRF or ICP. Sample locations were tracked using global positioning system (GPS) and entered into an interactive geographic database. Under the conditions of the sampling and analysis, a total of 46 properties had arsenic concentrations greater than or equal to 400 mg/kg and/or lead concentrations greater than or equal to 2,000 mg/kg. A total of 248 properties had arsenic concentrations ranging from 70 mg/kg to 399 mg/kg and/or lead concentrations ranging from 500 mg/kg 1,900 mg/kg. Four properties had lead concentrations greater than 2,000 ppm and no properties had lead concentrations greater than 4,000 mg/kg.

Complete physico-chemical characterization of the material which was collected is pertinent to understanding exposure and the risks posed by elevated metal concentrations in soil. For example, metals may be bound in a multitude of chemically and physically different matrices which might influence their solubility and bioavailability (fractional absorption across the gut). The particle size of the metal-bearing fraction of soil may also greatly influence the bioavailability and internal exposure to children or adults. Work is presently underway to fully characterize the samples collected as to particle size, organic carbon content, pH, chemical speciation, and matrix. In the absence of this information, EPA has reviewed recent studies conducted by the University of Colorado Department of Geology (CU) on soils in the vicinity of the present sampling effort (Drexler, 1998). For the protection of childhood health, and in the absence of direct characterization of the subject samples, it is plausible to assume that the physico-chemical characterization of soils in the immediate vicinity of the present sampling effort is likely to be representative of the samples collected by UOS.

The results of the CU study indicate that the frequency of occurrence of arsenic trioxide (As_2O_3) is on the order of 30% while the mass fraction of As_2O_3 in the vicinity soils is approximately 80%. There is a strong correlation (0.66) between As_2O_3 and arsenic antimony oxide (AsSbO) indicating the possibility that arsenic contamination in the area may be due to pyrometalurgical sources. As_2O_3 is highly oxidized. Because of this, arsenic is likely to be soluble and highly bioavailable to humans via the ingestion route of exposure. This bioavailability is enhanced by the relatively small particle size range characterized by CU scientists. The mean particle size for all arsenic species identified was 8 micrometers (μm). The mean particle size for the As_2O_3 phase was 9 μm *with a range from 1-200 μm. This information is highly relevant to the risk evaluation of soils in* the vicinity of Vasquez Blvd. And I-70 as it indicates that the arsenic is likely to be readily absorbed across the gastrointestinal tract and within a particle size (<250μm) expected to stick readily to hands, clothes, pet fur, and children's toys.

<u>Exposure of Residents to Metals in Soil</u>:

In order for exposure and risk to occur under current conditions, a complete exposure pathway must exist. Pathways of exposure to soil metals may be complex and multifaceted. For a complete exposure pathway to exist, there must be; 1) a source of contamination (metals in soil), 2) a release mechanism (e.g. bare soil areas or other possibility for release), 3) a transport of the soil contamination to a receptor (child or adult resident), and 4) an exposure route (ingestion, inhalation, or dermal absorption). Due to their atomic charge, metals are typically not well absorbed by the skin and this dermal route of exposure is usually insignificant in areas of soil contamination. Therefore, this route will not be discussed further in this memorandum. While exposure to metals in soil by inhalation can pose a significant threat in areas which are extremely dusty and human activity levels are high (such as in areas of active earth moving), this route of exposure is also far less significant in most residential exposure settings where there are not active smelter emissions. This is presently the case in the Vasquez and I-70 area and so this route of exposure will not be fully quantified in this memorandum.

In most cases where residential soil is contaminated with metals, the significant exposure route is through incidental ingestion of soil and dust. Soil and dust ingestion may be influenced by a variety of other environmental factors such as; 1) time spent outdoors, 2) amount of exposed bare soil, 3) proximity and condition of lead-based paints, 4) frequency of hand-to-mouth activity, 5) parental care, etc. Children and adults are typically exposed to soil and dust particle sizes less than approximately 250 micrometers in size as this particle size more readily adheres to hands, toys, and clothing. Sieving to this smaller particle size using a 60 mesh sieve may also reduce sample heterogeneity and slightly increase the measured metal concentration of the samples. EPA estimates that children may ingest an average of approximately 100 milligrams of soil and house dust per day (mg/day). This is due to common hand-to-mouth activity coupled with a tendency of children to be active at outdoor and indoor play. A reasonable upper bound estimate for childhood soil and dust ingestion used for this assessment is 200 mg/day. EPA assumes that adults may ingest 50 mg/day of soil and dust (EPA Exposure Factors Handbook).

Due to the chemical form of arsenic found in the neighboring community soils it is reasonable to assume that solubility of the material is relatively high and, as a consequence, fractional absorption of this material is correspondingly elevated. For the purpose of this assessment a range of absorption efficiencies of arsenic from soils of 50% to 80% relative to freely soluble arsenic in water will be used.

<u>Toxicity of Arsenic and Lead</u>:

Subchronic Arsenic Toxicity:

Most of the available peer reviewed literature which supports a scientific understanding of arsenic toxicity in humans is derived from cases of human exposure and resulting health effects following ingestion of arsenic contaminated water. Due to the likelihood of high bioavailability of the predominant arsenic species (As_2O_3), it is technically plausible (in the absence of data to the contrary) and protective of public health to assume that arsenic in these particular soils may be as toxiologically active as arsenic in several key toxicity studies.

Several studies address the question of short-term (from a few months up to five to seven years) exposure to arsenic. These studies were reviewed and discussed in detail by Region VIII toxicologists during September, 1995 (Benson, 1995). The nature of those discussions is reproduced herein.

The studies presented in this section represent those which describe non-cancer health effects related to arsenic exposure lasting from six months to 15 years. Assessment of short-term exposure to arsenic should only be undertaken in cases where chronic exposure is not likely or where steps to address chronic exposure to arsenic are expected. Health risk assessment which fully addresses the chronic aspects of arsenic exposure (carcinogenic effects) for these residential soils should be considered.

Tay and Seah (1975) provide a summary of 74 case histories from Singapore of arsenic poisoning attributed to the consumption of herbal preparations which contained arsenic sulfide or arsenic trioxide. Clinical findings in the individuals are consistent with symptoms known to be associated with arsenic intoxication. Ninety-two percent of the patients showed some form of cutaneous lesions (generalized hyperpigmentation, hyperkeratosis of palms and soles, "raindrop" depigmentation, palmar and plantar hyperhidrosis, multiple arsenical keratoses on trunk and limbs, mucous membrane lesions, diffuse alopecia, and Mee's lines in nails). The length of time the patients had ingested the herbal preparations varied from less than six months to approximately 15 years. 53% of the patients had ingested the preparations for one year or less and 84% of the patients had ingested the preparation for five years or less. The authors of this report estimated the dose of arsenic to be 3.1 milligrams per day (mg/day) in patients ingesting pills containing arsenic sulfide. The subchronic dose of arsenic necessary to cause an adverse effect is 0.06 - .2 mg/kg-day.

A series of papers in the peer reviewed literature discuss incidence of arsenic poisoning occurring in Antofagasta, Chile (Zaldivar, 1974; Zaldivar, 1977; Zaldivar and Guillier, 1977). The population was exposed to arsenic in drinking water and food. Of particular interest for derivation of a subchronic reference dose are the reports of skin lesions (leuko-melanoderma and/or hyperkeratosis of palms and soles, sometimes accompanied by scaling of the skin) in children. The children examined ranged in age from birth to 10 with a mean age of 1.7 years. Exposure time is assumed to be equal to the age of the child. Details of the examination of the children and the data used to derive the prevalence of disease in the population are not reported in the papers. The incidence of arsenic poisoning in the age group is reported to be 726.6 per 100,000. The calculated mean dose of arsenic for this age group is reported to be 0.063 mg/kg-day. This value was determined using the average measured concentration of arsenic in drinking water, the measured content of arsenic in a variety of foods, and the average body weight of the children. This publication documents adverse effects of arsenic observed following a subchronic dose of 0.06 mg/kg-day.

Borgono et al., (1980) describe the evaluation of 1277 school children (ten to 15 years of age) from different cities in the Antofagasta province of Chile. The study was conducted in 1977. The children were exposed to arsenic from the public water supply in the various communities and from food. The exposure time is not directly mentioned by the authors but is presumed to be equal to the age of the child. The results of the investigation are shown in the table below. The skin lesions observed included melanoderma, melanoleukoderma, hyperkeratosis of palms and soles, and peripheral vascular alterations (transient patches of cyanosis or white patches on the tongue, fingers, toes, and back of the hands and feet).

Location	Concentration of arsenic in drinking water (mg/l)	Incidence of Skin Lesions
Chuquicamata	0.08	4
Tocopilla	0.30	49
Maria Elena	0.30	54
Calama	0.30	19
Pedro De Valdivia	0.40	50

The authors of this study did not determine the amount of water or food-borne arsenic consumed by these individuals. Because the study was conducted in the same location as that reported by Zaldivar (1974 and 1977) and Zaldivar and Guillier (1977), it is reasonable to assume that the amount of arsenic ingested from drinking water and food are comparable. This study provides support for the conclusion that a subchronic dose of arsenic of 0.06 mg/kg-day is an effect level.

Huang et al., (1985) report an investigation of endemic arsenism in a plant in Kuitun area Xinjiang, China. The water supplying the plant came from a deep artesian well and contained 0.6 mg/l of arsenic. The well was first used in 1969. In 1982 the authors examined 336 individuals. One hundred and fifty people (44.6%) showed skin lesions characteristic of chronic arsenism. There was no control group. The lesions observed included dyspigmentation (diffuse brownish pigmented macules and spots mixed with depigmented areas) and keratosischiefly on the palms and soles. The exposure time in effected individuals ranged from six months to 12 years, but because no other symptoms presented with the cutaneous lesions, most patients failed to remember the exact time of onset of symptoms. Water consumption was not measured directly, but the authors stated that individuals drank more than two liters of water daily. The highest intake reported was eight liters daily. No information is provided on the arsenic content of the diet or on the body weight. Assuming an average consumption of water of five liters per day and a body weight of 50 kg, the dose of arsenic from drinking water is 0.06 mg/kg-day.

Two reports by Tseng (Tseng, 1968 and Tseng et al., 1977) were used to establish EPA's chronic reference dose. The lowest observed-effect level for skin lesions (hyperpigmentation and hyperkeratosis) was established at 0.014 mg/kg-day. Although not clearly reported, the data show a very strong increase in incidence of skin lesions with increasing time of exposure. See Tseng et al. (1968) Figures 5 and 6 and Tseng (1977) figure 6 and Tables 2, 4, and 6. These data strongly imply that an exposure duration of ten years or less at a dose of 0.014 mg/kg-day is a no-effect level for non-cancer endpoints. Taken together, these studies establish that adverse effects occur when people ingest for six months to 15 years a dose of 0.06 mg arsenic/kg-day. None of these studies adequately quantifies a no-observed-adverse-effect-level following subchronic exposure in people. Therefore, a subchronic lowest-adverse-effect-level of 0.06 mg/kg-day is coupled with and uncertainty factor of 10 for extrapolation to a subchronic no-observed-adverse-effect-level in humans.

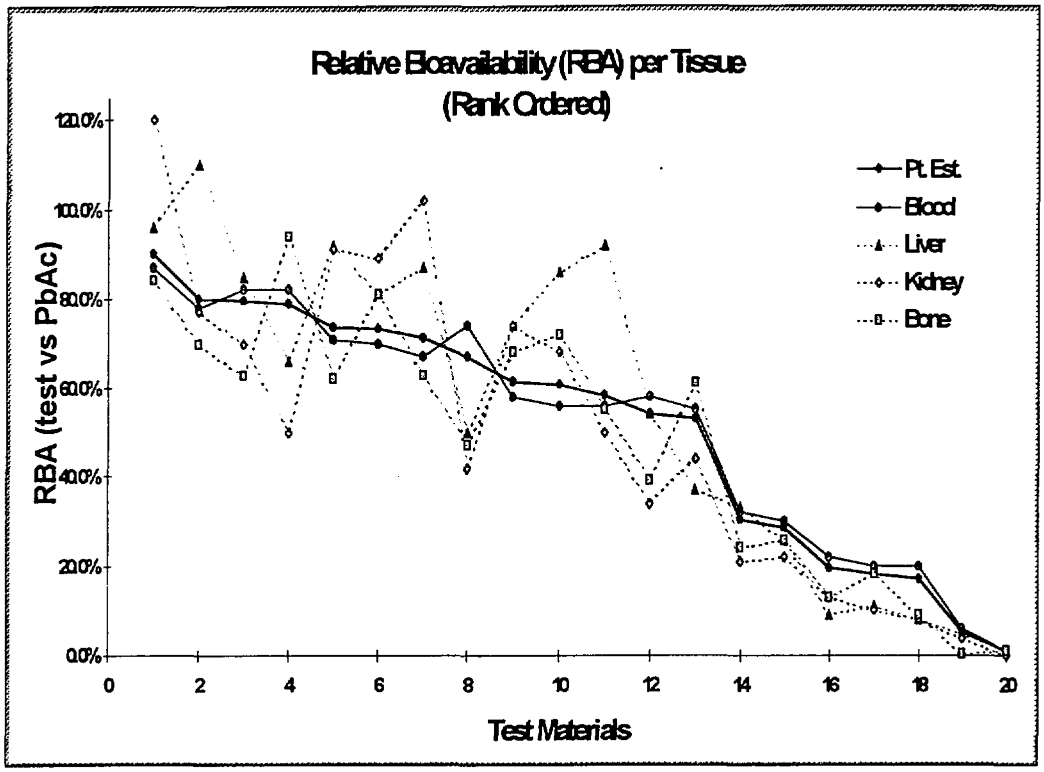
$$Subchronic\ RfD = \frac{0.06\ \frac{mg}{kg\text{-}day}\ (effect\ level)}{10\ (uncertainty\ factor)} = 0.006\frac{mg}{kg\text{-}day}$$

Lead:

Lead exposure in children is known to cause central nervous system effects resulting in learning disabilities, hearing impairment, and behavioral difficulties (Needleman, 1990). Children are particularly susceptable to the effects of lead due to: 1) the tendency for children less than the age of 7 to absorb lead much more efficiently than adults; 2) the particular susceptibility of the developing brain to the toxicological effects of lead, and 3) the tendency for children to be more highly exposed to possible sources of lead such as dust, soil and paint due to exploratory behavior. These effects have been demonstrated in large epidemiological studies to occur at blood lead levels of 10 micrograms per deciliter of blood (10 µg/dL). Needleman (1990) demonstrated the tendency for lead toxicity in children to persist long after exposure ends. It is not known how long exposure must occur for persistent effects to appear. However, seasonal exposure to environmental lead is sufficient to bring blood lead concentrations to semi-steady state as determined by pharmacokinetic studies in animals.

Adults in a residential setting are generally less exposed to the effects of lead due to lower absorption rates and generally less exposure. However, lead is known to redily cross the placenta with a transfer efficiency to the developing fetus of approximately 90%. Thus, pregnant women and women of child-bearing age are of concern in an environment conducive to excessive lead exposure. Typically, steps which are taken to reduce exposure of children to lead are also effective for reducing or eliminating adult exposure.

The absorption of lead from soils associated with the metal extraction industries is highly variable. Region VIII has tested the gastrointestinal absorption of several lead contaminated soils using an immature swine model as a surrogate for young children. The results of that investigation are summarized in the figure below. This study measured the relative bioavailability of lead in soils compared to the bioavailability of freely soluble lead acetate in water. The preliminary results indicate that lead in mine waste is highly variable relative to highly soluble lead acetate (Casteel et al, 1998). The range of relative bioavailabilities (RBA) measured in the study is from approximately 6% to approximately 86% compared with absorption of soluble lead. Most of the soil lead identified in communities adjacent to the Vasquez Blvd. and I-70 area is in the form of a relatively soluble arsenic lead oxide (AsPbO) with a mean particle size diameter of 4µm (range 1-100µm). AsPbO of this small particle size would be expected to have relatively high bioavailability. It is also likely that some fraction of the lead in North Denver soils derives from lead-based paint.



EPA employs an Integrated Uptake Biokinetic Model (IEUBK model) for assessing exposure to children in residential settings. This computer model employs estimation of the absorption, distribution, and excretion of lead in children to predict blood lead concentrations following exposure to environmental lead. When available, appropriately collected human biomonitoring information (blood lead measurements) is useful for determination of recent environmental exposure. Information regarding multiple sources of exposure such as lead in water or paint aid in the understanding of risk related to lead absorption by children. Using standard default exposure assumptions, the IEUBK model predicts an approximate 50% probability of children having blood leads greater than the Agency recommended limit of 10 µg/dL when soil lead concentrations exceed 2,000 ppm.

<u>Risk Characterization:</u>

Arsenic:

A range of risk-based exposure levels for short term exposure (6 months to 15 years) of children (2-3 years old) to arsenic can be established using the subchonic (non-cancer) toxicity information presented above coupled with site-specific and Agency default assumptions about the dose which might be ingested following exposure to soil and housedust in the neighborhoods of interest. Using a range of childhood body weights for children between the ages of 2 years and 6 years (11-16 kg) and a range of plausible absorption fractions for oxidized arsenic compounds (50 to 80%[1]), a corresponding range of risk-based soil levels can be established. Equation 2 and 3 were used to estimate risk-based exposure levels of concern for short term (6 months to 10 years) exposure to arsenic in residential soils.

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[1] Absorption (bioavailability) of soil arsenic has been measured in experimental animals. USEPA Region 8 toxicologists have recently released the results of a series of studies on the absorption of soil arsenic (Henningsen et al, 1998). The available data indicates that soil arsenic is less bioavailable than arsenic in water. However, estimates of soil arsenic absorption range from approximately 20% to as high as 100% relative to freely soluble arsenic.

Where:

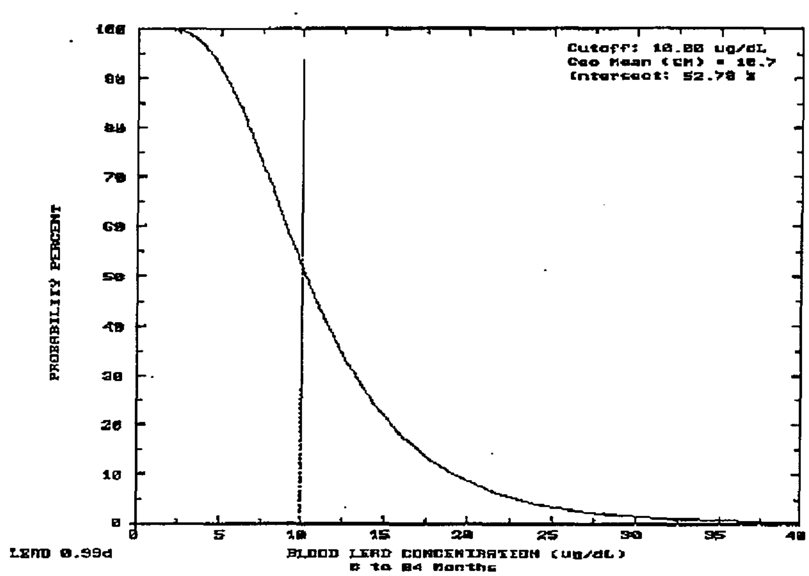
$$\text{Exposure Level} = \frac{\text{subchronic RfD}\ (\frac{mg}{kg\text{-}day}) \times \text{Body Weight}\ (kg)}{\text{Soil Ingestion Rate}\ (\frac{gms}{day}) \times \text{Absorbed Fraction}} \times \frac{1000\ ug}{1\ mg} \quad \mathbf{(2)}$$

Subchronic RfD = 0.006 mg/kg-day
Body Weight = 11-15 kg (child)
Soil Ingestion Rate = 0.2 grams/day
Absorbed fraction = 0.5 - 0.8 demensionless

$$\text{Exposure Level} = (412\text{-}900)\ \frac{mg}{kg} = \frac{0.006\ (\frac{mg}{kg\text{-}day}) \times (11 - 16)\ (kg)}{0.2\ (\frac{gms}{day}) \times (0.5 - 0.8)} \times \frac{1000\ ug}{1\ mg} \quad \mathbf{(3)}$$

The range of risk-based exposure levels of concern is from 412 mg/kg (ppm) to 900 mg/kg arsenic in soil. This range of risk-based exposures is applicable only for short-term, interim actions which might be taken to reduce or eliminate exposure to arsenic in soil. Due to the carcinogenic potential of arsenic, steps should be taken to assess the possibility of longer-term exposures above risk-based levels of concern.

To assure adequate protection of public health, it is recommended that any actions taken to reduce exposure to soil arsenic in this neighborhood focus on the lower end of this soil range. The rationale for providing a significant margin of protection is three fold: 1) As discussed previously, recently collected evidence available from near-by the site indicates that the arsenic bearing material may be of fine particle size and is likely to be very soluble and bioavailable. Efforts to improve our understanding of arsenic absorption on this site would be both expensive, technically complex, and would require significant time; 2) while the State of Colorado is presently conducting protective biomonitoring in neighboring communities, there is no similar program in place to monitor actual exposure in the vicinity of Vasquez Blvd. and I-70; and 3) while there is an interest in pursuing longer-term clean-up options for the site, there is presently no established activity underway to implement longer-term options.



Lead:

Using standard default exposure assumptions, EPA's IEUBK model predicts an approximate 50% probability that children's (0-84 months) blood lead will exceed 10 µg/dL when soil lead concentrations exceed 2000 ppm. This predicted blood lead probability is considerably greater than the EPA goal of not more than a 5% probability of a childhood blood level greater than 10 µg/dL. Medical monitoring for childhood blood lead has proceeded in the general vicinity of the Globeville smelter which is north and east of the neighborhoods of interest for this memorandum. A baseline study conducted in 1994 prior to soil remediation or community education. The results indicate relatively low blood lead concentration in children between the ages of 0-6 years. A summary of human biomonitoring conducted in the baseline monitoring program by the State of Colorado Department of Public Health and Environment in cooperation with the Agency for Toxic Substances and Disease Registry is presented in the table below. The data do not indicate that childhood lead exposure was excessive during the time that the samples were taken. This discrepancy between modeled and measured blood lead cannot be resolved with available data but is often noted in areas contaminated by mining and smelting wastes. In order to assure protection of childhood health steps should be taken to minimize exposures to soil lead concentrations greater than 2000 ppm. Additional exposure-based sampling would better define the nature of human exposure on the site and may better define the discrepancy between measured and modeled blood lead concentrations.

	number of individuals	average blood lead (µg/dL)	number of children >10µg/dL
Blood lead (0-6 years)	127	3.4	7 (5.5%)
Blood lead (>6 years)	799	2.9	0

Summary:

Recently collected surface soil data in the vicinity of Vasquez Blvd. and I-70 indicate the presence of elevated levels of arsenic and, to a lesser extent, lead. Levels of these levels exceed concentrations which may pose an imminent and substantial endangerment to human health following short term (6 months to 10 years) exposure. The primary exposure pathway is incidental ingestion of soil and dust by children in areas with poor ground cover or stressed vegetation where children may play. Steps should be taken to minimize exposure of children to arsenic in surface soils where levels are approximately 400 parts per million or greater. Lead exposure to surface soils greater than 2000 ppm are also of concern for children. Steps should be taken to minimize exposure of children to lead in surface soils where levels are approximately 2000ppm or greater.

cc: D. Skie
B. Murray
M. Dodson
B. LaVelle

References:

Benson, R., (1995) Memorandum from R. Benson to Christopher Weis, Subchronic Reference Dose for Arsenic. September 12, 1995.

Drexler, J. (1998) A study on the source of anomalous arsenic concentrations in soils from the Globeville community, Denver, CO June 9, 1998.

EPA (1996) Exposure Factors Handbook EPA/600/P-95/002Ba.

Henningsen, G., Weis, CP, Hoffman, E., Brattin, W., Christensen, S. (1998) Differential Bioavailability of lead mixtures from 20 different soil matrices at Superfund mining sites. *The Toxicologist.*

Huang, Y., Quian, X., Wang, G., Xiao, B., Ren, D., Feng, Z., Wu, J., Xu, R., and Zhang, F., (1985) Endemic chronic arsenism in Xinjiang. *Chinese Medical Journal* 98(3): 219-222.

Needlelman, H; Schell, A.;Bellenger, D.; Leviton, A.; Allred, E. (1990) The long-term effects of exposure to low doses of lead in childhood. *New England Journal of Medicine*, 322;83-88.

Rabinowitz, M.; Kopple, J.; Wetherill, G. (1980) Effect of food intake and fasting on gastrointestinal lead absorption in humans. Am. J. Clin. *Nutrition*. 33;1784-1788

Tay, C.H., and Seah, C. (1975) Arsenic poisoning from anti-asthmatic herbal preparations. *Med. J. Aust.* 2:424-428.

Tseng, W.P., 1997. Effects and dose-response relationships of skin cancer and blackfoot disease with arsenic. *Environ. Health Perspect.* 19:109-119.

Tseng, W.P., Chu, H.M., How, S.W., Fong, J.M., Lin, C.S., and Yeh, S. 1968. Prevalence of skin cancer in an endemic area of chronic arsenicism in Taiwan. *J. Natl. Cancer Inst.* 40:453-463.

URS Operating Services (UOS). 1998. Final Sampling and Analysis Plan. March 19, 1998.
Zaldivar, R., (1974) Arsenic Contamination of drinking water and food-stuffs causing endemic chronic poisoning. *Beitr. Path. Bd.* 151:384-400.

Zaldivar, R., (1977) Ecological investigations on arsenic dietary intake and endemic chronic poisoning in man: dose-response curve. *Zbl. Bakt. Hyg.*, I Abt. Org. B 164:481-484.

Zaldivar,R., and Guillier, A., (1977) Environmental and clinical investigations on endemic chronic arsenic poisoning in infants and children. *Zbl. Bakt. Hyg., I. Abt. Orig. B.* 165:226-234.

Attachment 2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
999 18TH STREET - SUITE 500
DENVER, CO 80202-2466

Ref: ENF-L

August 17, 1998

By Facsimile

Ms. Frances Hartog
Assistant Attorney General
Office of the Attorney General
State of Colorado
1525 Sherman St., 5th Floor
Denver, CO 80203

Dear Frances:

I have reviewed the ARARs the State of Colorado submitted to me for the removal action at what we are now calling the Vasquez-I70 site (the "Site"). As I have previously indicated to you in a phone conversation, the list does not distinguish between what the State believes to be applicable, versus what the State believes to be appropriate and relevant. Thus, I have had to draw my own conclusions about state law and regulations. In addition, the list appears to be a generic one used without much consideration as to how it might apply to the Site.

As you are aware, the Site's boundaries are as yet undefined. The remedial investigation/feasibility study will determine the nature and extent of contamination, which will in part define such boundaries. Given the current uncertainty related to boundaries, I have chosen to treat each residential cleanup as its own site for ARARs purposes. Thus, when reviewing the State's submission, I was looking for those regulations which would be meaningful for activities that actually occur within the boundaries of each individual residential property. This initial cut removed all of the hazardous materials and transportation regulations as ARARs, because no activities will occur within the residential property that are covered by such regulations. In addition, the State never provided the documents I requested indicating whether the State enacted the 1990 rulemaking on formerly Bevil excluded wastes, thus I would not be able to determine if the requirements were applicable.

A review of the State's regulations on air quality shows that the majority of them are meant to apply to stationary sources, not the small, short duration construction activities that are going to occur during this removal action. The only regulatory requirement which seemed to be applicable to the activities being performed was Regulation 1, 5 CCR 1001-3. This regulation applies to the control of fugitive particulate emissions, but is only applicable in a nonattainment area where the construction activities involve parcels greater than one acre. Thus, I have relayed to the technical team that this requirement may be relevant and appropriate for the removal action. Ultimately, the delegated decision-maker must make the decision on ARARs. I will provide that decision-maker with the State's submission, so that s/he can determine if any other State-identified ARARs should be used.

If EPA does perform a remedial investigation/feasibility study for the Site, the State will be requested to provide a much more detailed analysis of potential ARARs. I would expect that together, the State and EPA will have many more ARARs that would be appropriate for that larger remedial action.

Sincerely,

Matt Cohn

Matthew Cohn
Legal Enforcement Program

cc: Peter Stevenson
Bonita Lavelle

Vasquez/I-70 Removal ARARs

Due to the limited timeframe, this listing may be incomplete. We assume that EPA will identify Federal ARARs so many of these regulations have not been identified by the state. The state may identify additional ARARs or provide additional detail as time progresses.

Chemical Specific ARARs	
Colorado Hazardous Waste Management Regulations, 6 CCR 1007-3, part 261, Identification of Hazardous Waste	Excavated materials expected to meet TCLP characteristics must be characterized to determine if hazardous waste. If TCLP, materials must be handled and disposed of in accordance with hazardous waste requirements. no proof of promulgat standar
Colorado Air Quality Control Regulations, 5 CCR 1001-14 (ambient air standard for Total Suspended Particulate Matter; primary standard: 75 u/m3 annual geometric mean, 260 ug/m3 24-hr standard; secondary standard 60 ug/m3 annual geometric mean, 150 ug/m3 24-hr standard.	not for specific sources
National Ambient Air Quality Standards 40 C.F.R. part 50 including PM10, PM2.5	ditto
? Colorado Air Quality Control Regulations, 5 CCR 1001-10, Regulation 8 (ambient air standard for lead; monthly average concentration must be less than 1.5 ug/m3.)	Stationary source
Action-Specific ARARs	
Colorado Solid and Hazardous Waste Disposal Sites and Facilities Regulations, 6 CCR 1007-2, (solid waste provisions.)	Must be achieved for disposal of any solid waste materials.
Colorado Hazardous Waste Management Regulations, 6 CCR 1007-3, part 262 (standards applicable to generators of hazardous waste.)	Must be achieved for any hazardous wastes generated.
Colorado Hazardous Waste Management Regulations, 6 CCR 1007-3, part 263 (standards applicable to transporters of hazardous waste.)	Must be achieved for any hazardous wastes transported.
Colorado Hazardous Waste Management Regulations, 6 CCR 1007-3, part 264 (standards applicable to owners and operators of treatment, storage and disposal facilities.)	Must be achieved for any hazardous wastes stored, treated, or disposed.
Colorado Rules and Regulations Concerning Transportation of Hazardous Materials, 8 CCR 1507.	Must be achieved for any hazardous wastes transported.

Federal Hazardous Materials Transportation Regulations, 49 C.F.R., parts 107, 171-177	Must be achieved for any hazardous wastes transported.
Colorado Air Quality Control Regulations, 5 CCR 1001-2-1001-14. (Common provision regulations, implementing regulations. Establishes standards for controlling fugitive particulate emissions, odors, and air toxics.)	Must be achieved for control of emissions, odors, and toxics from construction activities. ?
Colorado Air Quality Control Regulations, 5 CCR 1001-3, Regulation 1 (establishes emission control regulations and opacity standards for particulate matter, requires minimization of fugitive particulate emissions from construction activities, requires submission of fugitive particulate emission control plan.)	Must be achieved for control of dust, emissions from construction activities. RFA
Colorado Noise Abatement Statute, 25-12-101 to 103, C.R.S.	Must be achieved for construction activities. HvL?
Colorado Air Quality Control Regulations, 5 CCR 1001-4, Regulation 2. (Establishes odor emission regulations. Systems to be designed to provide odor-free operation.)	Must be achieved for construction activities. where is odor likely from this operation?
Colorado Air Quality Control Regulations, 5 CCR 1001-5, Regulation 3. (Requires analysis of air pollution impacts prior to start of project; Air Pollution Emission Notice (APEN) to be filed; source cannot cause an exceedance in any attainment area of any National Ambient Air Quality standard; source cannot interfere with attainment and maintenance of any state ambient air quality standard; source to undergo review procedure which estimates public health impacts from toxic pollutants.)	Must be achieved for construction activities, except for particulate matter standards which are routinely exceeded throughout the Denver metropolitan area. See notes for Part A not ARAR Part B - only applies to stationary sources
Colorado Air Quality Control Regulations, 5 CCR 1001-10, Regulation 8. (Sets forth emission control requirements for hazardous air pollutants, including lead.)	Must be achieved for construction activities applies to stationary sources not RFA either
Criteria for municipal solid waste landfills. 56 F.$. 59978, October 9, 1991 (codified at 40 C.F.R. 258.)	Must be achieved when managing solid wastes.

Attachment 3

ENFORCEMENT CONFIDENTIAL

Enforcement Addendum
North Denver Residential Soils (SSID #9R)

(b) (7)(A)

[redacted]